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DISEASE RESISTANCE SCREENING FOR SPRING WHEAT BREEDING PROGRAMS AT THE UNIVERSITY OF SASKATCHEWAN

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DISEASE RESISTANCE SCREENING FOR SPRING WHEAT BREEDING PROGRAMS AT THE UNIVERSITY OF SASKATCHEWAN

Final Report

February 9, 2004 to January 1, 2010

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SUMMARY

Disease resistant varieties provide farmers an economical means of managing crop diseases. The development of new varieties involves generating and testing numerous breeding lines for a variety of agronomic, quality, and disease resistance traits. This project evaluated over 65,000 spring and durum wheat breeding lines for their reaction to the following diseases prevalent in western Canada: leaf rust, stem rust, common bunt, loose smut, leaf spot complex, and Fusarium head blight (FHB). The disease reaction information was provided to the CDC spring and durum wheat breeders to aid in selection of breeding lines that meet the requirements for variety registration. Thirty-six breeding lines were also identified with leaf rust, stem rust, and FHB resistance amongst progeny of crosses that introgressed FHB resistance from exotic wheat lines from around the world.

INTRODUCTION

Wheat diseases decrease grain yield and quality. Effective disease management can be achieved by a number of different means depending on the specifics of the particular disease. Disease resistant varieties are an important tool in disease management. In addition to the benefits of improved crop productivity, the use of disease resistant varieties reduces reliance on and need for the use of fungicides for disease management. Reduced fungicide application translates into lower input and labour costs for the farmer, and reduced environmental footprint of crop production.

New crop varieties are developed through plant breeding. For wheat, this involves cross-pollinating wheat lines, developing inbred lines from the progeny, and selecting for desirable traits in the inbred lines. Desirable traits are often broken out into agronomic, quality, and disease/pest resistance traits. Selection is a sequential process by which undesirable lines are eliminated, beginning with traits that can be evaluated cheaply and are not highly influenced by the environment. In spring wheat, this would include plant height (and thereby lodging resistance), leaf rust resistance, and stem rust resistance. In durum wheat, the emphasis would be on plant height and leaf spotting resistance. Breeding lines that survive the first round of selections are then tested for traits that more expensive to evaluate (ie. require replicated testing and/or laboratory tests).

The primary objective of this project was to support the disease resistance evaluation of spring and durum wheat breeding lines developed by the Crop Development Centre, University of Saskatchewan. Breeding lines would be evaluated for resistance against economically important diseases of wheat in western Canada, namely those that are considered in the variety registration system (leaf rust, stem rust, common bunt, loose smut, leaf spot complex, FHB). The second objective of this research was to evaluate FHB resistance in breeding lines specifically developed to introgress FHB resistance from exotic wheat lines from around the world.

METHODS

Leaf and Stem Rust

The leaf and stem rust nurseries were grown under irrigated conditions using two nursery designs. Breeding lines in advanced stages of yield testing were planted in short rows (1 m), while breeding lines in early stages of yield testing were planted in hills spaced 30 cm apart. The test entries were not replicated. Within the test entries, checks were seeded every 28 plots in the short row nursery, and every 40 plots in the hill nursery. For 2004 to 2007 nurseries, the checks were AC2000, AC Barrie, CDC Teal, and McKenzie. During these years, AC2000 was moderately susceptible to leaf rust and moderately resistant to stem rust, AC Barrie was moderately susceptible to leaf rust and moderately resistant to stem rust, CDC Teal was moderately resistant to leaf rust and moderately resistant to intermediate for stem rust, and McKenzie was resistant to leaf rust and moderately resistant to stem rust. For the 2008 and 2009 nurseries, the checks were Marquis, Neepawa, CDC Teal, and AC Cora. During these years, Marquis was susceptible to leaf and stem rust, Neepawa was susceptible to leaf rust, CDC Teal was moderately resistant to leaf rust and moderately resistant to intermediate for stem rust, and AC Cora was resistant to leaf and stem rust. Rust spreader rows were seeded to a mixture of leaf and stem rust susceptible varieties. Both nursery designs were seeded in groups of 35 rows with spreader rows seeded in 1st, 18th and 35th row.

Plants in the spreader rows were inoculated during vegetative growth with a mixture of races of leaf rust and stem rust spores suspended in Bayol. Dr. Brent McCallum and Dr. Tom Fetch (AAFC-Winnipeg) provided leaf rust and stem rust inoculum representing the current prevalent races of the respective pathogens. From 2004 to 2006, airbrush inoculators were used to inoculate spreaders rows at 2 m intervals. White plastic bags, moistened with distilled water in the inside, were fastened over the inoculated plants. The bags were removed 16-18 hours later. Beginning in 2007, spreaders rows were inoculated using a combination of airbrush inoculators and Micron Herbaflex herbicide applicators. The latter inoculation method inoculated the entire spreader row. In 2007 and 2008, infection was reliant upon natural leaf wetness from precipitation or overnight dew. In 2009, a plastic tarp system was developed that was similar to the plastic bags used with the airbrush inoculators. Inoculations were done in the afternoon to limit the time the plants were exposed to high temperatures while covered with plastic bags.

Secondary disease cycles spread the leaf and stem rust from the inoculated spreader rows to the test entries. Irrigation was applied as necessary to ensure the leaf and stem rust epidemics continued over the growing season.

Plants were rated for leaf rust reaction when good differentiation is observed between the resistant and susceptible checks, and prior to senescence of the flag leaf. For 2004 to 2006, flag leaves of advanced breeding lines were rated using a six-class rating scale: VR (very resistant), R (resistant), MR (moderately resistant), MRMS (intermediate), MS (moderately susceptible), and S (susceptible). These rating were based on a combination of leaf rust severity and infection type. Normally a MR rating was considered the minimum acceptable level of resistance. For 2007 and 2008, flag leaves were rated for leaf rust severity and infection type. In 2009, leaf rust severity data was recorded. Acceptable lines had leaf rust severities scores similar to CDC Teal (MR) or better. Early generation breeding lines were rated as either acceptable or discard based upon the reaction of the flag leaf. Acceptable entries had a leaf rust reaction similar to CDC Teal (MR) or better.

Stem rust ratings were made when plants were near maturity and were based upon stem rust severity on wheat stems. Advanced breeding lines were rated on a four-class scale: R (resistant, no stem pustules), MR (moderately resistant, better than stem rust check), I (intermediate, similar to stem rust check), or S (susceptible, worse than stem rust check). The stem rust check was AC Barrie for 2004 to 2006 and CDC Teal for 2007 to 2009. Early generation breeding lines were rated as either acceptable or discard. Acceptable entries had a stem rust reaction similar to CDC Teal or better.

Common Bunt

Common bunt evaluation was restricted to lines in the advanced stage of yield testing. The disease nurseries were planted as hill-plot nurseries. Hills were seeded with 50 seeds and were spaced 45 cm apart. Each test included the check varieties Columbus (resistant), Neepawa (intermediate), and Laura (susceptible).

The day before seeding, the seed for each hill plot was dusted with a mixture of bunt teliospores of *Tilletia tritici* races T-1, T-6, T-13, T-19 and *T. laevis* races L-1 and L-16 in an approximate ratio of 1:1:1:1:2:2. The nurseries were seeded in late April to ensure the cool soil temperatures needed for infection. Just prior to maturity, the plots were visually rated for bunt

infection. Disease reaction was expressed as percent bunted tillers. Resistant and susceptible reactions were determined by the infection level on the check varieties. Statistical analyses were used to compare the reactions of the test lines with those of the checks.

Loose Smut

Testing for loose smut reaction was done in the greenhouse. Each entry was grown to flowering and inoculated with a suspension of teliospores of appropriate loose smut races; races T2, T9, T10, and T39 for common wheat and races T26, T32, and T33 for durum wheat.

In 2004 to 2007, inoculations were performed with a needle injection method. Five to eight heads were selected for inoculation when the anthers extruded from the central florets begin to turn white. Before inoculation, each head is prepared as would be done before manual pollination; only 20 primary florets in the central region of the head were retained. Each floret was inoculated by injecting spore suspension through the palea with a hypodermic syringe until the floret was filled with inoculum. The inoculated heads are marked and the plants grown to maturity.

In 2008 and 2009, inoculations were performed with a partial vacuum inoculation protocol (Nielsen 1983). This protocol required less labour. Four heads were selected for inoculation when the anthers extruded from the central florets begin to turn white. These heads were placed in the inoculation chamber. The vacuum was engaged to fill the chamber with the teliospore suspension. Once the chamber was filled with inoculum, vacuum was quickly engaged three times to draw air out of the florets. Release of the vacuum sucked inoculum inside the florets. The inoculated heads were marked and the plants grown to maturity.

Seed from the inoculated heads of an entry was harvested and 50 seeds per entry were planted in pots in the greenhouse. Plants were rated for infection at heading by counting the number of plants with smutted heads. The disease reaction was expressed as percent smutted plants.

Leaf Spotting Complex

Testing for reaction to the leaf spot complex was done in naturally-infected disease nurseries grown at the Goodale Research Farm where the leaf spot complex is endemic. The three major leaf spot diseases (tan spot, stagonospora nodorum blotch, and septoria tritici blotch) occur,

although in differing proportions according to the seasonal conditions. Plot dimensions varied between years and tests. From 2004 to 2006, plots were 2 rows, 2 m long. For 2007 to 2009, breeding lines in all wheat types, except the miscellaneous wheats, were evaluated as yield plots (5 rows, 4.45 m^2). For 2008 and 2009, miscellaneous wheats, were evaluated as single 1 m rows. Individual tests were set up in a randomized complete block design with two or three replicates.

Tests were rated when leaf spot symptoms had developed sufficiently on susceptible checks and when most entries were transitioning from the milk to dough stage of kernel development. This ensured that leaf spot lesions had time to develop and that leaf senescence did not confound ratings. In 2004 to 2006, plots were rated using a 1-9 rating scale, which is based on the extent of disease development on the lower, middle and upper leaves. The higher the disease has progressed up the plant, the higher the disease rating and the lower the level of resistance. In 2007, all plots were rated using a 1-9.5 rating scale (Shaner and Buechley 1995), similar to 1-9 scale above. A subset of plots was rated on the basis of percent diseased tissue on the flag and flag-1 leaves. In 2008 and 2009, plots were evaluated for percent diseased flag leaf area in all tests.

Fusarium Head Blight (FHB)

Screening of advanced breeding lines did not fall within the scope of this project. However, this project did have the objective of identifying sources of resistance that could be used as parental material in the breeding programs. Such lines were evaluated for FHB resistance in field nurseries at Carman, Manitoba, in association with Dr. Anita Brûlé-Babel (University of Manitoba). In addition to natural infection, the nurseries were artificially inoculated with infected maize kernels and/or spore suspension during July and mist irrigation was applied regularly to enhance disease development. Resistant and susceptible checks were included at regular intervals within the tests. Plots were rated visually about three weeks after the last inoculation for mean % head infection and % heads infected; these two values are multiplied to give the FHB Index for that entry.

RESULTS

The project generated disease reaction data on over 65,000 breeding lines developed by the spring and durum wheat breeding programs at the Crop Development Centre, University of Saskatchewan. Table 1 summarizes the number of breeding lines, by wheat marketing class, tested for reaction to leaf and stem rust, common bunt, loose smut, leaf spot complex, and FHB. Evaluation for reaction to leaf rust and stem rust began on the early generation breeding lines, whereas, testing for reaction to the other diseases began at the advanced breeding line stage. This resulted in many more lines being evaluated for reaction to leaf rust and stem rust than the other diseases. The number CWAD breeding lines was reduced in 2007 to provide more space for evaluation of breeding lines in the CWRS, HWW, CPS, and GP wheat classes. Generally, rust resistance in durum wheat is stable year-to-year and the progeny of most crosses are resistant. Since this is not true of other wheat classes, a reallocation of resources would make the CDC spring wheat breeding programs more efficient. This project did not provide funding for FHB testing in Carman, Manitoba, but provided funding for seed setup of entries tested in Manitoba in 2004 and 2005. These entries were doubled-haploid progeny of crosses designed to incorporate FHB resistance from exotic germplasm. Field testing of these lines ended in 2005. In 2006 and beyond, the Manitoba FHB nursery space that was used to evaluate these lines was then reallocated to the CDC spring and durum wheat breeding programs for evaluation of additional advanced breeding lines in these programs.

Figure 1 presents the percentage of early generation breeding lines that were discarded on the basis of poor leaf rust or stem rust resistance in the years 2004 to 2009. The discard rate was 40% on average over these years, and ranged from 32% to 45%. Breeding lines surviving early generation selections were then considered advanced breeding lines in future growing seasons. Figures 2 and 3 present the leaf rust ratings of advanced breeding lines in 2004 to 2006 and 2007 to 2009, respectively. In 2004 to 2006, a rating of MR or better would be considered acceptable for leaf rust resistance. However for 2007 to 2009, breeding lines would have to have a leaf rust rating similar to CDC Teal to be considered acceptable (Table 2). Given these criteria, the discard rate based upon leaf rust in advanced breeding lines was 25% on average, and 18%, 34%, 50%, 24%, 11%, and 11% in 2004, 2005, 2006, 2007, 2008, and 2009, respectively. A high level of leaf rust resistance is expected for the advanced breeding lines since these lines were

Table 1. Number of breeding lines, by marketing class, evaluated for disease reaction.

Disease, Marketing Class[a]	2004	2005	2006	2007	2008	2009	Total
Leaf and Stem Rust							
CWRS	6,132	4,408	5,076	5,597	4,231	7,414	32,858
HWW	2,512	828	711	892	2,285	3,399	10,627
CPS / GP	211	936	962	1,509	2,081	2,769	8,468
CWAD	1,523	2,401	1,521	305	450	474	6,674
Spelt	136	50	18	18	19	171	412
Misc.	2,079	1,994	1,407	448	988	567	7,483
Total	12,593	10,617	9,695	8,769	10,054	14,794	66,522
Common Bunt							
CWRS	177	106	113	119	113	85	713
HWW							
CPS / GP	208	108	98	134	282	290	1,120
CWAD							
Spelt	8	7	10				25
Misc.						15	15
Total	393	221	221	253	395	390	1,873
Loose Smut							
CWRS	64	42	49	91	76	48	370
HWW							
CPS / GP	208	72	98	128	282	241	1,029
CWAD	72						72
Spelt	8	7	10	8	7	10	50
Misc.							
Total	352	121	157	227	365	299	1,521
Leaf Spot Complex							
CWRS				94	372	344	810
HWW						64	64
CPS / GP		72					72
CWAD		50	45	96	433	497	1,121
Spelt				18	7	10	35
Misc.	2,311	362			98	126	2,897
Total	2,311	484	45	208	910	1,041	4,999
Fusarium Head Blight							
CWRS							
HWW							
CPS / GP							
CWAD							
Spelt							
Misc.	1,000	589					1,589
Total	1,000	589					1,589
Total	12,593	10,617	9,695	8,769	10,054	14,794	66,522

[a]CWRS = Canada Western Red Spring; HWW Hard White Wheat; CPS = Canada Prairie Spring; GP = General Purpose; CWAD = Canada Western Amber Durum; Misc. = miscellaneous wheat types.

previously selected for leaf rust resistance in early generation tests. The relatively high discard rates in 2005 and 2006 likely resulted from races changes in the *Puccinia triticina* population relative to 2004 and earlier. Typical symptoms of leaf rust are shown in Figure 4.

Figure 1. Percent discarded early generation breeding lines from 2004 to 2009.

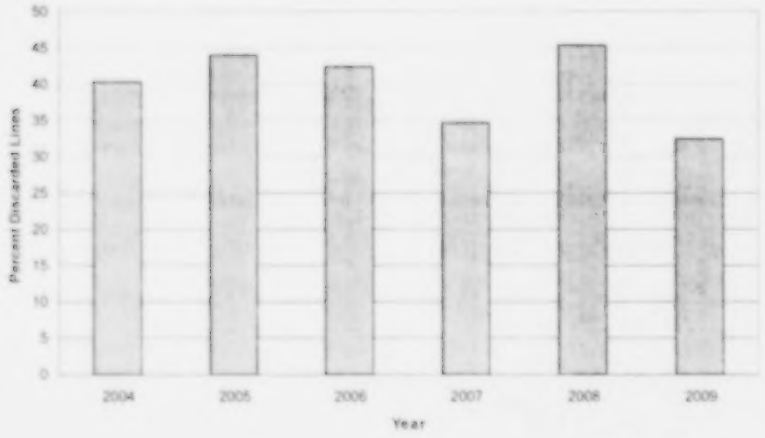


Figure 2. Leaf rust ratings of advanced breeding lines in 2004 to 2006.

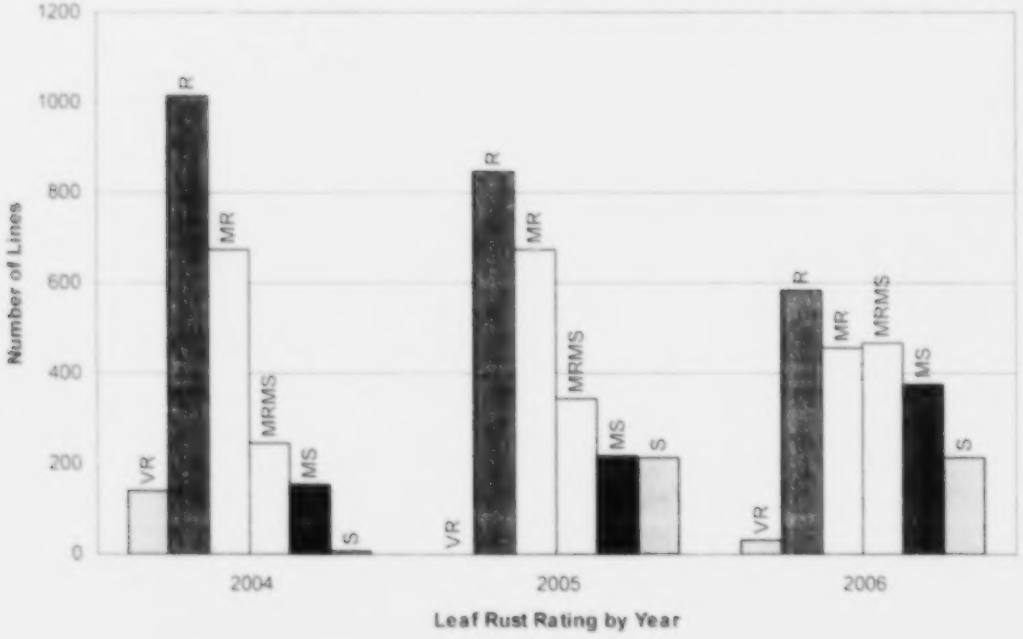


Figure 3. Leaf rust severity of advanced breeding lines in 2007 to 2009.

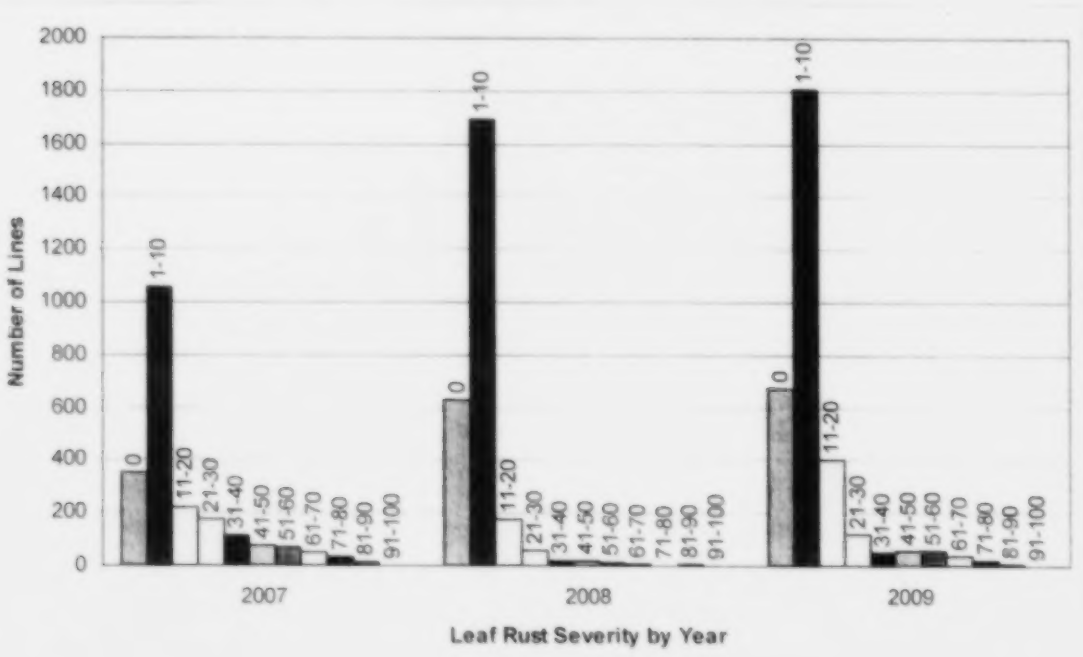


Table 2. Average leaf rust severity and infection type of check lines from 2007 to 2009.

Check	2007	2008	2009
AC2000	52.4 MS		
Marquis		23.5 MS	44.0 MS
AC Barrie	54.3 MS		
Neepawa		25.4 MS	65.0 S
CDC Teal	11.2 MR	4.0 MR	11.3 MR
McKenzie	4.2 R		
AC Cora		1.0 R	0.3 R

Figure 4. Leaf rust pustules on the check Neepawa in the 2008 leaf and stem rust nursery.

Stem rust data on advanced breeding lines is presented in Figure 5. Using a susceptible rating as the criterion for discard, the stem rust discard rate was 17% on average, and 7%, 21%, 29%, 13%, 17%, 16% in 2004, 2005, 2006, 2007, 2008, and 2009, respectively. The year-to-year the discard rate was relatively consistent for stem rust, which is consistent with the stable *Puccinia graminis* f.sp. *tritici* population over the period. The variation in the discard rate likely resulted from the specific crosses present in nurseries of particular years and/or varying amounts of stem rust development in the rust nurseries year-to-year. Interestingly, the highest discard rate in advanced breeding lines was in the 2006 growing season for both leaf rust and stem rust. Figure 6 shows typical symptoms of stem rust on wheat stems.

Figure 5. Stem rust ratings of advanced breeding lines in 2004 to 2009.

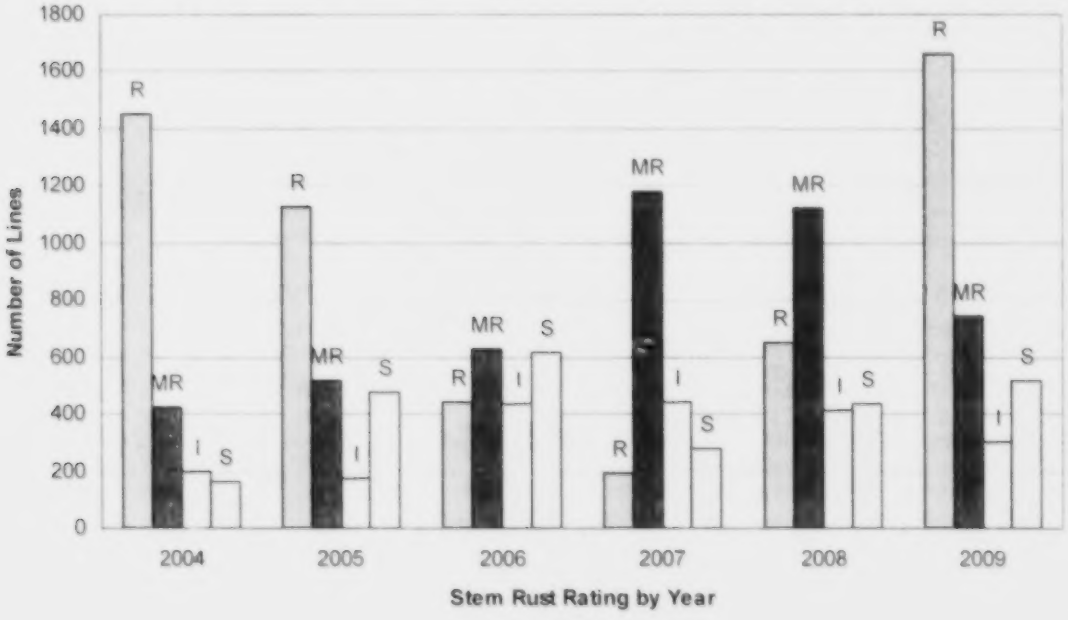


Figure 6. Stem rust pustules on the stems of Marquis in the 2008 leaf and stem rust nursery.

Figure 7 presents common bunt data on advanced breeding line from 2004 to 2009. Check means are presented in Table 3. The common bunt infection rate varied year-to-year as shown by the infection of the check lines. The relative ranking of the checks was consistent with expectations. Neepawa possesses an intermediate level of common bunt resistance and is considered the minimum desirable level of common bunt resistance. Using Neepawa as a cut-off, the common bunt discard rate was 28% on average, and 41%, 26%, 26%, 28%, 23%, and 23% in 2004, 2005, 2006, 2007, 2008, and 2009, respectively.

Figure 7. Percent common bunt-infected tillers of advanced breeding lines in 2004 to 2009.

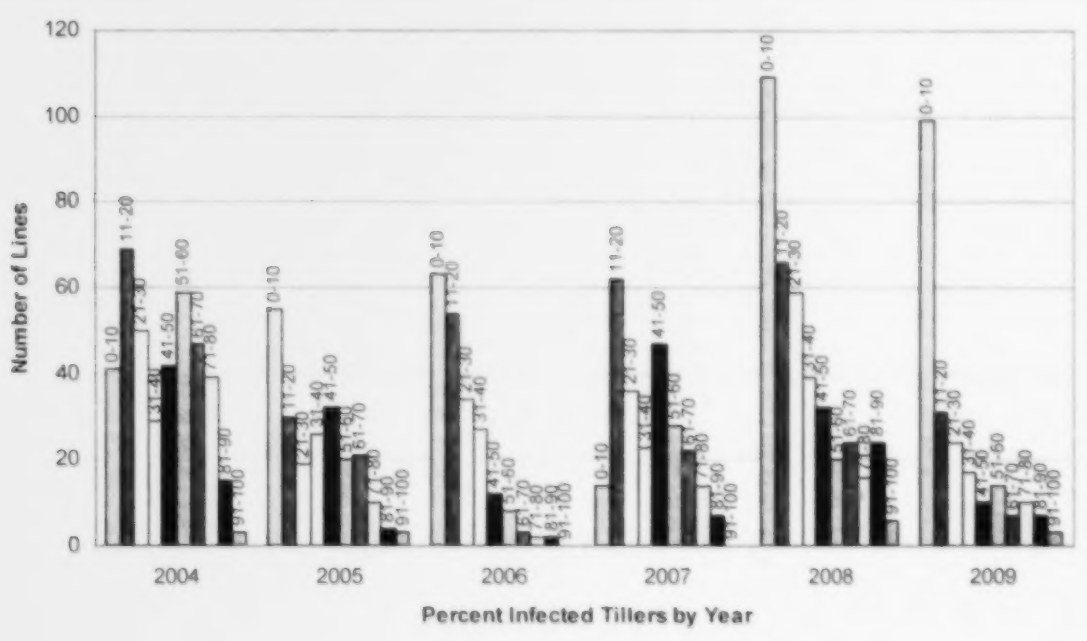
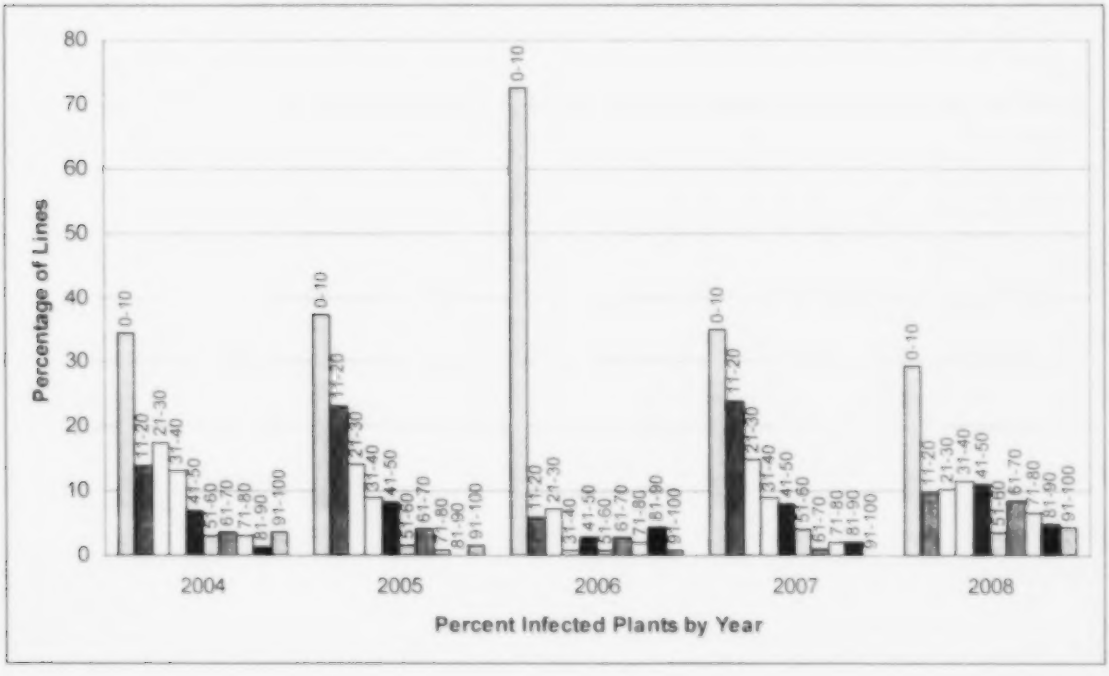


Table 3. Average percent common bunt-infected tillers for check lines in 2004 to 2009.

Check	2004	2005	2006	2007	2008	2009
Columbus	29.8	13.8	16.8	45.8	28.3	14.4
Neepawa	52.8	52.5	25.5	54.6	50.6	33.8
Laura	75.2	78.6	56.0	71.7	53.3	54.7

Loose smut data on the advanced breeding lines present in disease tests from 2004 to 2008 is presented in Figure 8. Data was not available for the 2009 test at the time of preparation of this report because loose smut evaluation requires two generations of plants. Loose smut data is collected in late January to early February of the year following testing of the other diseases. Loose smut infection of the check lines is presented in Table 4. Variation in loose smut infection rates for the checks is likely the result of disease escape. This can result as the result of selecting heads for inoculation that are not at the optimal stage for loose smut infection. The loose smut rating for a breeding line in the coop testing system is the worst rating that the line receives over the three years of testing. Using a loose smut rating of 30% as the discard cut-off, the loose smut discard rate was 30% on average, and 34%, 26%, 14%, 26%, and 51% in 2004, 2005, 2006,

Figure 8. Percent loose smut-infected plants of advanced breeding lines in 2004 to 2008.



2007, and 2008, respectively. The low discard rate and the number of lines in the 0-10% infected class in 2006 suggests a higher rate of disease escape than is typical. The higher discard rate for 2008 is the result of the increased number of CPS breeding lines being evaluated in 2008 relative to previous years. In general, CPS wheats have less loose smut resistance than CWRS wheats.

Table 4. Average percent loose smut-infected plants for check lines in 2004 to 2008.

Check	2004	2005	2006	2007	2008
AC Avonlea	66.0				
AC Morse	36.4				
Commander	36.4				
Strongfield	34.5				
AC Barrie	57.7	13.5	8.8	31.4	15.3
AC Elsa	3.6	5.9	6.7	28.6	
AC Splendor	9.1	25.0	9.1	20.5	14.3
AC Superb	11.0	22.8	7.9	11.9	23.4
AC Vista	23.4	3.8	0.0	42.3	
CDC Teal					29.0
Glenlea					0.0
McKenzie					53.4

Figure 9 presents the severity of leaf spotting lesions on flag leaves of advanced breeding lines evaluated in 2008 and 2009. The means of the check lines are presented in Table 5. Leaf spot severity was similar between these years as shown by the levels of infection on the spring wheat check lines. However, the durum wheat checks did show a lower infection rate. Using 20% severity as the discard cut-off, the mean discard rate was 21% and 8% in 2008 and 2009, respectively. The lower discard rate in 2009 was the result of lower leaf spot scores on the durum wheats in 2009 relative to 2009. Typical leaf spotting lesions are shown in Figure 10.

Figure 9. Leaf spot severity of advanced breeding lines in 2008 and 2009.

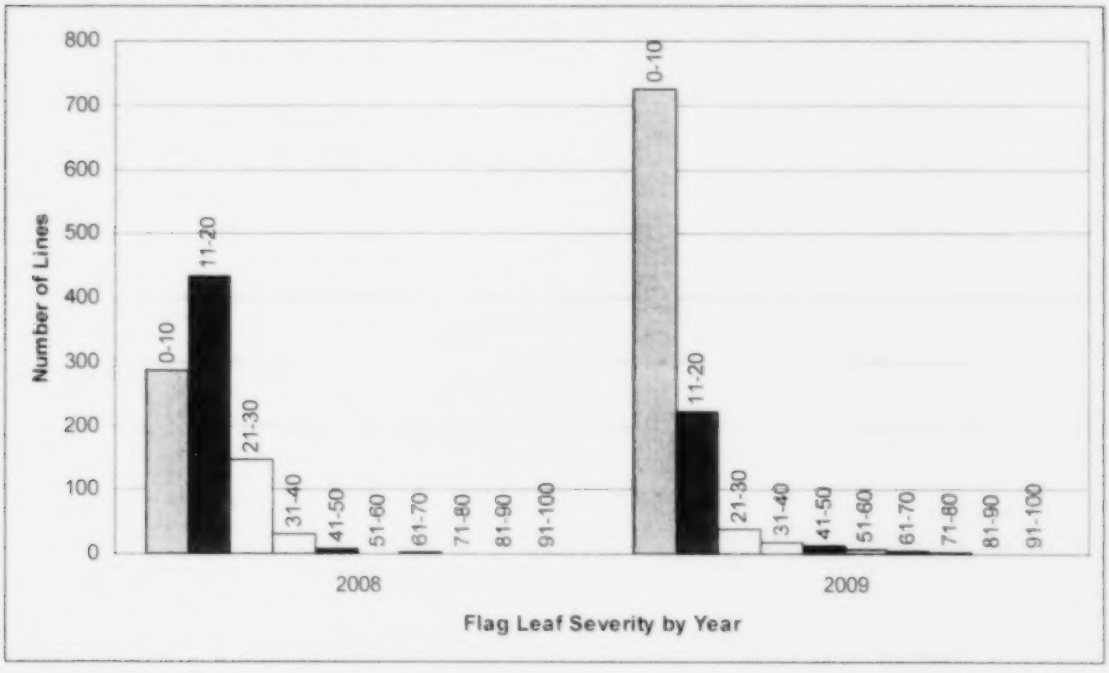
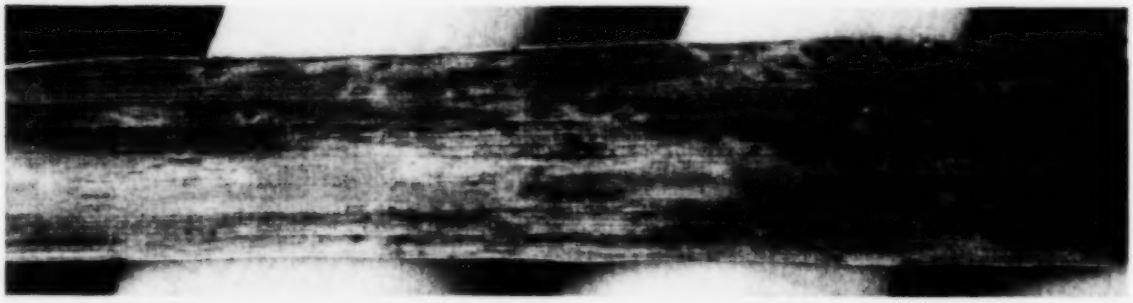


Table 5. Average leaf spot severity on flag leaves of check lines in 2008 and 2009.

Check	2008	2009
AC Barrie	13.8	11.9
AC Splendor	14.4	16.9
Lillian	2.7	3.5
Superb	16.8	14.0
AC Morse	22.7	7.8
AC Navigator	14.9	13.2
Commander	18.9	16.0
Strongfield	12.8	6.4

Figure 10. Leaf spot lesions on typical flag leaf of CDC Teal at the Goodale Research Farm in 2008.



FHB resistance is an important breeding objective in the development of new wheat varieties. FHB resistance has been identified in a number wheat lines from around the world (McCartney et al. 2004), but are not suitable for production in western Canada. A number of doubled haploid (DH) populations were developed from crosses involving FHB resistant wheat lines. One thousand doubled haploid lines of such crosses were evaluated for leaf rust, stem rust, and FHB resistance in 2004. A subset of these lines were selected to be re-evaluated for leaf rust, stem rust, and FHB resistance in 2005. In addition, 142 putatively FHB resistant wheat lines were evaluated in 2005. Table 6 presents the best doubled haploid progeny from these experiments. These thirty-six lines possess acceptable leaf rust and stem rust resistance and appear to have reduced FHB susceptibility based upon two years of data. Highlighted in red are concerning data points on these lines. The sixteen DH lines at the top of the table likely have the most merit in terms of FHB resistance. FHB resistance did not appear to be associated with increased plant height since some of the best FHB resistant lines had a relatively short plant height. Most of the exotic FHB resistance sources are tall. This data suggests that plant height is not related to FHB resistance, which is consistent with previous genetic analyses (Waldron et al. 1999; Buerstmayr et al. 2003; Somers et al. 2003). These lines were made available to the CDC wheat breeders for further evaluation.

Table 6. Best progeny of crosses incorporating Fusarium head blight resistance evaluated in 2004 and 2005.

Cross	Line	2004 Height	2004 LR	2005 LR	2004 SR	2005 SR	2004 FHB Index	2005 FHB Index
CDC Bounty / J9625415H (01-37)	76	124	R	MR	R	I	0.5	0.3
Domain // Domain/FHB SYN #1 (01-60)	42	89	R	MR	R	R	0.5	0.5
CDC Teal // AC Intrepid / MN 93413 (02-39)	9	[illegible]	R	MR	R	R	0.5	0.5
Domain // Domain/FHB SYN #1 (01-60)	56	[illegible]	MR	MR	R	R	0.5	2.0
CDC Bounty / J9625415H (01-37)	69	[illegible]	R	MR	R	MR	0.3	2.5
Bounty/MN93413 //Teal/ND2710 (00-68)	59	[illegible]	MR	R	R	R	4.0	0.5
Domain // Domain/FHB SYN #1 (01-60)	21	97	R	R	R	MR	5.0	0.0
BW205/ND2710//BW205 (98-2)	148B	[illegible]	MR	MR	R	R	4.5	0.5
Domain // Domain/FHB SYN #1 (01-60)	7	[illegible]	VR	R	R	R	3.0	2.3
Bounty/MN93413 //Teal/ND2710 (00-68)	57	100	MR	MR	MR	R	6.0	0.3
Bounty/MN93413 //Teal/ND2710 (00-68)	56	92	MR	MR	R	R	6.0	0.3
CDC Teal // AC Intrepid / ND 2710 (02-41)	8	115	R	R	R	R	6.0	2.0
CDC Teal // Fusarium BW #1 (02-40)	17	109	R	MR	R	MR	8.0	0.5
CDC Teal // Fusarium BW #1 (02-40)	23	85	R	MR	R	R	8.0	0.5
Bounty/MN93413 //Teal/ND2710 (00-68)	53	95	MR	MR	R	R	9.0	0.5
Domain // Domain/FHB SYN #1 (01-60)	41	95	MR	MR	R	R	9.0	1.0
CDC Teal // AC Intrepid / ND 2710 (02-41)	9	118	R	R	R	R	0.5	12.0
BW264/Wangshuibai (01-38)	23	121	R	R	R	MR	1.5	11.9
Domain // Domain/FHB SYN #1 (01-60)	15	103	MR	nd	R	R	12.0	1.0
CDC Bounty / Wangshuibai (01-40)	25	113	MR	MR	MR	R	6.0	8.0
CDC Teal // AC Intrepid / MN 93413 (02-39)	3	95	MR	MR	R	R	14.0	0.5
CDC Teal / Wangshuibai (01-34)	8	127	R	R	MR	MR	4.0	12.0
Bounty/MN93413 //Teal/ND2710 (00-68)	62	105	R	R	R	R	7.5	10.0
BW205/ND2710//BW205 (98-2)	152B	104	MR	R	R	R	8.0	11.3
Wangshuibai/CDC Teal (98-20)	78	120	R	R	R	R	7.5	12.3
CDC Teal // Fusarium BW #1 (02-40)	24	105	R	MR	R	I	20.0	0.3
Bounty MN93413 //Teal/ND2710 (00-68)	52	95	R	R	MR	R	0.3	20.0
CDC Teal // AC Intrepid / MN 93413 (02-39)	18	97	R	MR	R	MR	20.0	0.5
AC Elsa/ND2710//Teal/BacUp (98-10)	97	96	R	MR	R	MR	12.0	8.8
Domain // Domain/FHB SYN #1 (01-60)	58	107	R	R	R	R	20.0	1.0
J962415H/CDCTeal (00-47)	6	101	R	R	R	MR	8.0	14.0
BW205/ND2710//BW205 (98-2)	160A	104	R	R	R	R	6.0	17.5
Teal/ND2710//Teal/MN93413 (98-11)	42	112	MR	MR	R	MR	15.0	10.0
BW205/ND2710//BW205 (98-2)	39A	99	R	MR	R	R	20.0	7.5
BW205/ND2710//BW205 (98-2)	39B	100	R	MR	R	R	12.0	15.8
CDC Bounty / Wangshuibai (01-40)	7	108	R	MR	MR	MR	16.0	12.0
AC Barrie	check	96.7	MS	MS	I	I	nd	26.9
AC Cora	check	105.7	R	R	R	R	35.2	34.2
AC Morse	check	nd	nd	nd	nd	nd	46.1	44.8
AC Vista	check	nd	nd	nd	nd	nd	65.3	52.8
CDC Teal	check	98.9	RMR	R	MR	MR	53.9	62.1
FHB 37	check	nd	nd	nd	nd	nd	7.2	5.1
ND 2710	check	114.3	MRMS	MR	R	R	3.0	1.3

Table 6. Best progeny of crosses incorporating Fusarium head blight resistance evaluated in 2004 and 2005.

Cross	Line	2004 Height	2004 LR	2005 LR	2004 SR	2005 SR	2004 FHB Index	2005 FHB Index
CDC Bounty / J9625415H (01-37)	76		R	MR	R	I	0.5	0.3
Domain // Domain/FHB SYN #1 (01-60)	42	89	R	MR	R	R	0.5	0.5
CDC Teal // AC Intrepid / MN 93413 (02-39)	9		R	MR	R	R	0.5	0.5
Domain // Domain/FHB SYN #1 (01-60)	56		MR	MR	R	R	0.5	2.0
CDC Bounty / J9625415H (01-37)	69		R	MR	R	MR	0.3	2.5
Bounty/MN93413 //Teal/ND2710 (00-68)	59		MR	R	R	R	4.0	0.5
Domain // Domain/FHB SYN #1 (01-60)	21	97	R	R	R	MR	5.0	0.0
BW205/ND2710//BW205 (98-2)	148B		MR	MR	R	R	4.5	0.5
Domain // Domain/FHB SYN #1 (01-60)	7		VR	R	R	R	3.0	2.3
Bounty/MN93413 //Teal/ND2710 (00-68)	57		MR	MR	MR	R	6.0	0.3
Bounty/MN93413 //Teal/ND2710 (00-68)	56	92	MR	MR	R	R	6.0	0.3
CDC Teal // AC Intrepid / ND 2710 (02-41)	8		R	R	R	R	6.0	2.0
CDC Teal // Fusarium BW #1 (02-40)	17		R	MR	R	MR	8.0	0.5
CDC Teal // Fusarium BW #1 (02-40)	23	85	R	MR	R	R	8.0	0.5
Bounty/MN93413 //Teal/ND2710 (00-68)	53	95	MR	MR	R	R	9.0	0.5
Domain // Domain/FHB SYN #1 (01-60)	41	95	MR	MR	R	R	9.0	1.0
CDC Teal // AC Intrepid / ND 2710 (02-41)	9		R	R	R	R	0.5	
BW264/Wangshuibai (01-38)	23		R	R	R	MR	1.5	
Domain // Domain/FHB SYN #1 (01-60)	15		MR	nd	R	R		1.0
CDC Bounty / Wangshuibai (01-40)	25		MR	MR	MR	R	6.0	8.0
CDC Teal // AC Intrepid / MN 93413 (02-39)	3	95	MR	MR	R	R		0.5
CDC Teal / Wangshuibai (01-34)	8		R	R	MR	MR	4.0	
Bounty/MN93413 //Teal/ND2710 (00-68)	62		R	R	R	R	7.5	
BW205/ND2710//BW205 (98-2)	152B		MR	R	R	R	8.0	
Wangshuibai/CDC Teal (98-20)	78		R	R	R	R	7.5	
CDC Teal // Fusarium BW #1 (02-40)	24		R	MR	R	I		0.3
Bounty/MN93413 //Teal/ND2710 (00-68)	52	95	R	R	MR	R	0.3	
CDC Teal // AC Intrepid / MN 93413 (02-39)	18	97	R	MR	R	MR		0.5
AC Elsa/ND2710//Teal/BacUp (98-10)	97	96	R	MR	R	MR		8.8
Domain // Domain/FHB SYN #1 (01-60)	58		R	R	R	R		1.0
J962415H/CDCTeal (00-47)	6		R	R	R	MR	8.0	
BW205/ND2710//BW205 (98-2)	160A		R	R	R	R	6.0	
Teal/ND2710//Teal/MN93413 (98-11)	42		MR	MR	R	MR		
BW205/ND2710//BW205 (98-2)	39A	99	R	MR	R	R		7.5
BW205/ND2710//BW205 (98-2)	39B		R	MR	R	R		
CDC Bounty / Wangshuibai (01-40)	7		R	MR	MR	MR		
AC Barrie	check	96.7	MS	MS	I	I	nd	26.9
AC Cora	check	105.7	R	R	R	R	35.2	34.2
AC Morse	check	nd	nd	nd	nd	nd	46.1	44.8
AC Vista	check	nd	nd	nd	nd	nd	65.3	52.8
CDC Teal	check	98.9	RMR	R	MR	MR	53.9	62.1
FHB 37	check	nd	nd	nd	nd	nd	7.2	5.1
ND 2710	check	114.3	MRMS	MR	R	R	3.0	1.3

CONCLUSIONS AND RECOMMENDATIONS

This project supported the disease resistance evaluation of over 65,000 spring and durum wheat breeding lines developed by the University of Saskatchewan. Breeding lines were evaluated for their resistance to leaf rust, stem rust, common bunt, loose smut, leaf spot complex, and FHB using the same protocols used in the evaluation of breeding lines in the coop testing system as part of the PGDC (Prairie Grain Development Committee), and the former PRRCG (Prairie Registration Recommending Committee for Grain). The disease reaction information was provided to the CDC spring and durum wheat breeders to aid in selection of breeding lines that meet the requirements for variety registration.

The disease reaction data (not including FHB data) that was collected as part of this research project would result in the recommendation to discard approximately 73% of all the breeding lines that proceeded to the advanced breeding lines status. Additional advanced breeding lines would be discarded on susceptibility to FHB, poor agronomic performance, and poor grain quality. When the early generation breeding lines from rust tests are included, the cumulative discard rate would be approximately 84%. The high discard rate for disease traits alone underlines the challenges faced by wheat breeders in the development of new varieties.

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Presentations:

McCartney C.A. 2009. Protecting crops through breeding and genetic research. Saskatchewan Agriculture – Agronomy Update, Saskatoon, Saskatchewan, 16 December 2009.

McCartney C.A. 2008. Cereal Rusts. Saskatchewan Agriculture – Agronomy Update, Saskatoon, Saskatchewan, 10 December 2008.

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